

-SQA- SCOTTISH QUALIFICATIONS AUTHORITY

HIGHER NATIONAL UNIT SPECIFICATION

GENERAL INFORMATION

Unit Number	D3R7 04
Unit Title	PROGRAMMABLE CONTROLLERS
Superclass Category	VE
Date of Publication (month and year)	
Originating Centre for Unit	Cleveland Open Learning Unit

DESCRIPTION

GENERAL COMPETENCE FOR UNIT:

Using programmable controller technology in an industrial context.

OUTCOMES:

1. describe the general features of a programmable controller system;
2. analyze the interface requirements of programmable controller systems;
3. write and execute programs to drive a programmable controller in industrial related tasks;
4. fault diagnose in a programmable controller environment.

CREDIT VALUE: 1 HN Credit

ACCESS STATEMENT:

Access to this unit is at the discretion of the centre. It would, however, be beneficial if the student had competence in basic electrical and electronic principles microprocessor systems. Evidence of such competence could be the successful completion of NC modules in these disciplines or other similar qualifications or experience.

Additional copies of this unit can be obtained from: The Administrative Services Unit, SQA, Hanover House, 24 Douglas Street, Glasgow G2 7NQ (Tel: 0141-242 2166).

At the time of publication, the cost is £2.50 (minimum order £5.00)

RANGE STATEMENT

Interface requirements:	isolation; input voltage; output voltage; output current; a.c. inputs; a.c. outputs; analogue and digital I/O; multiplexing.
Man-machine interface:	keyboard; display; I/O data emulation (i.e. data I/O image table).

EVIDENCE REQUIREMENTS

PC (a)	Written and or oral evidence of the student's ability to describe the range of requirements.
PC (b)	One correct solution involving an opto-coupler circuit and one for a relay output circuit.
PC (c)	Two calculations to demonstrate the student's understanding of resolution and bit width.
PC (d)	One correct solution to demonstrate the student's understanding of the operation of the network.
PC (e)	Written and or oral evidence of the student's ability to describe the features of keyboards, display devices and I/O data emulation.

OUTCOME**3. WRITE AND EXECUTE PROGRAMS TO DRIVE A PROGRAMMABLE CONTROLLER IN INDUSTRIAL RELATED TASKS****PERFORMANCE CRITERIA**

- The relationship between source code (ladder diagram) and its object code is clearly demonstrated.
- Ladder logic programs, employing a variety of control elements, are valid solutions to given control problems.
- Program documentation is clear and accurate.
- Program execution fulfils all the requirements of a given specification.

RANGE STATEMENT

Control elements:	NO contact; NC contact; latch; timer; counter; shift register; start; stop.
Control problems:	hardware initialization; reset; event sequencing; event timing; event/process duration; event counting.
Documentation:	system description (written and diagrammatic); ladder diagram; allocation of inputs and outputs; description of program operation.

EVIDENCE REQUIREMENTS

PC (a)	Written and or oral evidence to show that the student can relate ladder logic to the object code generated.
PC (b), (c) & (d)	Written and graphical evidence that the student can create a minimum of two programs, supported by the necessary documentation, to satisfy the range of control problems and performance evidence of their correct execution. One program should be of a complexity that involves at least an interdependent triple sequencing of hardware.

OUTCOME

4. FAULT DIAGNOSE IN A PROGRAMMABLE CONTROLLER ENVIRONMENT

PERFORMANCE CRITERIA

- (a) The symptoms of a fault are reported accurately.
- (b) Discrimination between cause and effect is performed in a systematic and logical fashion.
- (c) Remedial action recommended for the correction of a fault is appropriate.

RANGE STATEMENT

Symptoms: spurious inputs; outputs failing to respond; system lockup; loss of sequence; loss of event timing/duration.
Fault: permanently open contact; permanently closed contact; faulty sensor; faulty solenoid; faulty connections.

EVIDENCE REQUIREMENTS

Performance and written and/or oral evidence of the student's ability to effectively describe and efficiently diagnose the malfunction of a programmable controller system displaying the symptoms caused by fault conditions given in the range statement.

MERIT

To gain a pass in this unit, a candidate must meet the standards set out in the outcomes, performance criteria, range statements and evidence requirements.

To achieve a merit in this unit, a candidate must demonstrate a superior or more sophisticated level of performance. In this unit this might be shown in the following ways:

- (a) showing a critical awareness of current trends in the use of programmable controllers in an industrial environment;
- (b) writing programs that are efficient, well structured and easily maintainable;
- (c) making effective use of a programmable controller's diagnostic aids;
- (d) successfully diagnose two or more simultaneously applied faults;
- (e) evidence of further reading outwith the given course material.

ASSESSMENT

In order to achieve this unit, candidates are required to present sufficient evidence that they have met all the performance criteria for each outcome within the range specified. Details of these requirements are given for each outcome. The assessment instruments used should follow the general guidance offered by the SQA assessment model and an integrative approach to assessment is encouraged. (See references at the end of support notes.)

Accurate records should be made of the assessment instruments used showing how evidence is generated for each outcome and giving marking schemes and/or checklists, etc. Records of candidates' achievements should be kept. These records will be available for external verification.

SPECIAL NEEDS

Proposals to modify outcomes, range statements or agreed assessment arrangements should be discussed in the first place with the external verifier.

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HIGHER NATIONAL UNIT SPECIFICATION**SUPPORT NOTES****Unit Number****Unit Title**

PROGRAMMABLE CONTROLLERS

SUPPORT NOTES:

This part of the unit specification is offered as guidance. None of the sections of the support notes is mandatory.

NOTIONAL DESIGN LENGTH:

SQA allocates a notional design length to a unit on the basis of time estimated for achievement of the stated standards by a candidate whose starting point is as described in the access statement. The notional design length for this unit is 40 hours. The use of notional design length for programme design and timetabling is advisory only.

PURPOSE

This unit introduces students to the basic features of a programmable controller, its interface requirements and the methods of programming them for simple industrial applications.

CONTENT/CONTEXT

The following information gives further clarification regarding the context in which the outcomes and performance criteria are to be achieved.

Corresponding to the Outcome:

1. Outcome 1 is intended to give a general overview of how a programmable controller works, showing how it is based upon microprocessor technology. Method of storing programs and data (i.e. types of memory) and how the programmable controller interfaces to the 'outside world' should be discussed. The student would benefit from a simple exposition of the fetch-execute cycle of the microprocessor. Discussion of relay logic and its associated ladder logic can serve to give programmable controller programming methods a historical context and serves to highlight the advantages of programmed control (including versatility, reduced costs, reliability, compactness, reduced power consumption, maintainability, adaptability along with all the other advantages associated with the programmable digital devices and computer technology).
2. Outcome 2 introduces the need for electrical isolation of the programmable controller when working in an industrial environment from both dangerous voltages and from electrical noise. The need for data conversion and the means for achieving it are also broached upon. The R/2R ladder network serves as an example of D/A conversion and the student should be able to analyze this circuit. Calculation of resolution, used to show the source of quantization error, are limited to

$$1\text{LSB} = \frac{\text{FSR}}{2^n - 1} = \frac{\text{FSR}(\text{nom})}{2^n}$$

where 1LSB is the magnitude of the analogue resolution, n the number of bits in the binary code and FSR and FSR(nom) the practical and nominal full scale ranges respectively.

Opto-coupler: regard should be paid to the magnitude and polarity of the input voltage (including mains a.c.). Calculations are limited to determining current and voltages values or component values in a simple circuit comprising of a series and shunt resistors to an LED.

Relay output: driving transistor with a relay load and commutating diode.

The programmer's interaction with the programmable controller is covered under the generic title of 'man-machine interface'. This includes means of inputting data (i.e. keyboard) and observing the output state of the controller (LEDs, seven-segment displays, monitors, etc.). Descriptions of methods of software emulation of I/O should also be given. Emphasis should be placed both upon the actual equipment to be used and what is likely to be found in industry.

- Outcome 3 involves the program design and execution. Whilst problems should be based upon industrial processes it is not the intention, primarily for reasons of safety, that the programmable controller is used to drive actual industrial systems. Rather, mimics and models should be used; these should be as realistic as possible.

Possible programming examples could include:

- control of hydraulic rams
- mixing of materials fed to a hopper
- control of conveyor belts
- startup/shut down sequence for motor, generator, pump or compressor
- control of traffic lights
- control of machine tools
- temperature control of oil/gas fired furnace.

The association of source and object code can be made by, for example, making a program listing of a simple (containing only NO and NC contacts) ladder diagram.

Typically, the order of complexity of a system should involve half a dozen interdependent inputs and outputs and the programs of 30 rungs or more. The stipulation of triple interdependent sequencing would be realized by, for example, three conveyors (or tanks) the movement (filling/draining) of which depends upon the state of both the previous and subsequent belts (tanks).

- Outcome 4: propriety kits may well have 'switched faults' that can be used to satisfy the requirements of this outcome. Otherwise, the lecturer will have to induce faults into the hardware to satisfy the range. The applied faults should as far as possible simulate those that might be realistically expected to occur in the actual system the mimic or model represents.

APPROACHES TO GENERATING EVIDENCE

The student should be given the opportunity to gain as much practical experience in programming a programmable controller as possible. This can be achieved by setting short programming exercises as a prelude leading up to more formidable project assignments. Manuals for the programmable controller being used should be available and the student encouraged to consult them.

ASSESSMENT PROCEDURES

Centres can use the Instruments of Assessment that are considered by the tutor to be the most appropriate.

Unit No.

Continuation

Outcome 1 could be assessed by the use of a short answer, matching, or multiple-choice style questions on the advantages of using programmable controllers. The remainder of the outcome can be satisfied by the drawing and describing a block diagram of a controller containing all the required features.

Outcome 2 could be assessed by a written and oral test on the problems of interfacing and on the 'man-machine' interface. The remaining outcomes must be assessed by the solving of numerical problems.

Outcome 3: PC (a) could be assessed by translating a ladder diagram snippet into object code. Alternatively, a machine listing of the object code could be produced and related to the ladder diagram. The rest of the outcome can be assessed by setting two mini projects relating to the industrial applications of programmable controllers.

Outcome 4 can be integrated into Outcome 3 by setting faults on the systems used in the projects.

REFERENCES

1. Guide to unit writing.
2. For a fuller discussion on assessment issues, please refer to SQA's Guide to Assessment.
3. Information for centres on SQA's operating procedures is contained in SQA's Guide to Procedures.
4. For details of other SQA publications, please consult SQA's publications list.

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